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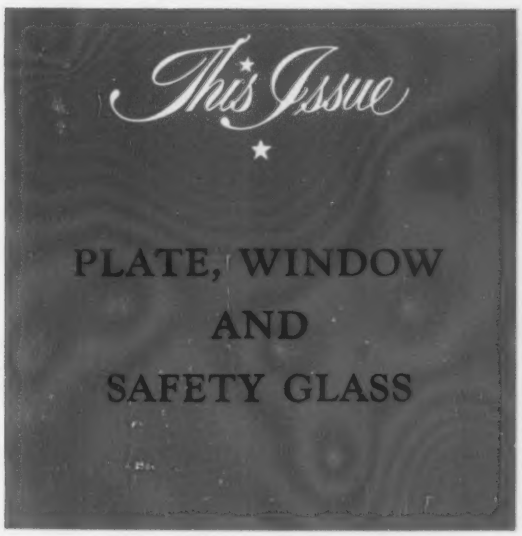
Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants



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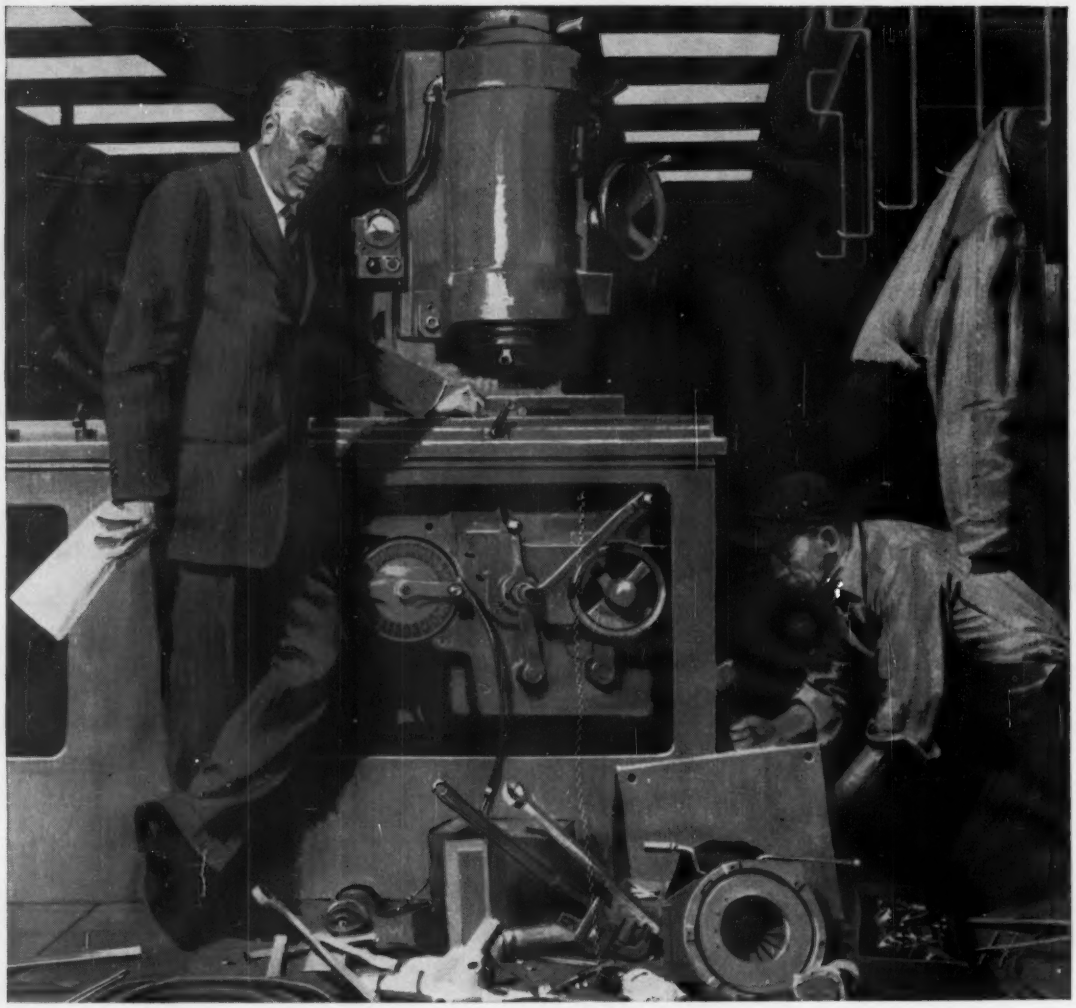

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Plate, Window and Safety Glass

GLASS[1] found in the natural state is known as *obsidian* and goes back to the earth's formative era. This glass, which was fused in the volcanic fires, had the appearance of brilliant common stones. These were usually translucent and blackish in color, but sometimes red, brown, or greenish, and some variations were transparent. Obsidian was easily broken into sharp elongated pieces which the Indians used to make arrowheads, spearheads and knives. In more advanced cultures it was used for ceremonial purposes and jewelry. Strangely enough, it wasn't until centuries after the advent of recorded history that man began to make glass.

There is little written evidence concerning the beginnings of the gigantic modern glass industry. According to the Roman naturalist, Pliny, who lived in the First Century A.D., the glass making process was discovered accidentally. Legend has it that it was discovered by a group of Phoenician sailors in about 5000 B.C. who landed on a sandy Mediterranean shore. Several blocks of soda ash from the ship's cargo were set up around the fire to support their cooking pot. When the heat from the fire became intense, the sand on the beach and the soda ash fused and molten glass flowed from the fire. The glistening material awed the sailors who took it to a port in Syria and reported their discovery.

There is also evidence that other places such as Syria and Egypt were the birthplace of glass making. Although the Phoenician story might not be authentic, it is believed that glass making probably did come about in a similar manner. There are definite indications that the Egyptians and Syrians made glass before the Christian era. About 1200 B.C. the Egyptians learned how to press glass into open molds. This replaced the sand-core method of making bowls, cups and dishes which consisted of winding rods of hot softened glass around a central core of sand built up on a metal rod. Such a core could be dipped into a pot of molten glass several times to build the glass up to the desired thickness.

Somewhere between 20 and 300 B.C. one of the greatest discoveries by mankind was the invention of the blowpipe. In the hands of skilled workmen an endless variety of hollow glass objects can be made using this simple device. A "gather" is made by dipping the knob-shaped end of the blowpipe into hot viscous glass: as the blowpipe is removed, a mass of hot glass adheres. The worker blows through the mouthpiece gently or vigorously and the gather can be blown into a thick or thin hollow bulb. Through swinging and rotating this bulb, rolling, manipulating and reheating as it cools in working, a hollow vessel of just about any symmetrical shape can be made. This method is still used today to make the very finest articles.

[1] In his book, "Properties of Glass", (page 25), George W. Morey defines glass in terms of only those characteristics which are essential to glass. "A glass is an inorganic substance in a condition which is continuous with and analogous to, the liquid state of that substance, but which, as the result of a reversible change in viscosity during cooling, has attained so high a degree of viscosity as to be for all practical purposes, rigid".

By the first century A.D., it appears that the Romans developed the first translucent glass windows. These were made by dropping molten glass upon a stone dusted with sand and flattened by several men pulling at it from all sides with pincer-like instruments. Very shortly thereafter they produced the first transparent sheets of glass by using the blowpipe to make small irregularly shaped cylinders. The cylinders were then slitted lengthwise and flattened after reheating.

In 331 A.D. it is reported that sheets of plate glass were produced by casting on a large flat stone. This type of production is probably the earliest forerunner of modern glass manufacture.

About the fifteenth century the center of the glass industry shifted to Constantinople. By the time Columbus discovered America, glass making had become an important industry. Toward the end of the seventeenth century, the English were producing *flint* glass for windows for which they became noted. Lead oxide was the ingredient used to give this glass its great brilliancy and comparative "softness" which made it easy to form and decorate. The name "flint glass" came from the use of very pure silica in the form of flint. Today the term "flint glass" is used to refer to any clear glass or to an optical glass having higher refractive index and greater dispersive power than certain other optical glasses. In places such as Bohemia, Sweden, and Silesia, great quantities of fine objects have been made from cut and etched glass.

About 1688 the process of casting plate glass was invented by the French. The process consisted of pouring molten glass from pots and rolling it into large sizes on iron tables. The surfaces of the large plates were ground and polished by hand. This gave France supremacy in the manufacture of large polished plate glass for many years.

The Owens bottle machine was invented about 1895 and was a great contribution to the bottle making industry.

Today there are four basic types of glass made.

1. Flat Glass – This can either be sheet (window) or plate glass and is called flat glass because it is originally made flat.
2. Blown Glass – These products include objects which are blown into shapes such as bottles, light bulbs, etc.
3. Pressed Glass – Products made with the use of molds or other means to press glass into shape fall into this category. Examples are glass blocks, lens blanks and cooking dishes.
4. Special Glasses–Included in this line are fiber glass, tubing, scientific glassware, etc. which require specialized processes.

A glass factory was the first manufacturing establishment in America. It is reported that in 1608 Captain Christopher Newport brought to James Towne, Virginia, among passengers on his ship, eight Dutch and Polish glass makers. After they arrived, a "glass house" was built close to this little Virginia settlement. Some of its products were among those in the first cargo exported from America in 1609. Bottles and small panes for windows of homes were the first products of this glass house. Later they also made colored beads and other articles used in trading with the Indians.

As a memorial, the Jamestown Glass Foundation has erected a glass house similar to the original structure built by the early glass makers. Today, as shown in Figure 1, workers attired in Colonial dress produce various objects in the same manner as they were made 350 years ago. As can be seen, the tools used were crude. The basic tools were the furnace, blowpipes, shears, tongs, molds, flat stone and blowpipe rolling guides. These workmen are shown making hollow ware.

Glass manufacture in America was very unsuccessful from the earliest times up until the latter part of the 19th Century. Many discouragements and setbacks were experienced for several reasons. The major reason was the fact that there were very few trained workmen in America, therefore all skilled craftsmen had to be imported from Europe. Then at times when success of an American undertaking was just about realized, European manufacturers would reduce prices below cost to be more competitive. In addition, on many occasions glass was singled out in some of the American Colonies and taxed exorbitantly.

Despite these difficulties, the glass industry in America survived. Today it leads the world in pioneering new and vital uses of glass in almost all branches of science and industry. It also leads the world not only in quality but in quantity produced.

This article will be confined to the production of flat glass. As mentioned previously this is either plate glass or window glass (known also as sheet glass). These two glasses differ in the following respects:

1. The chemical composition is slightly different although both are essentially soda-lime-silica glasses.
2. Much plate glass is made by the semicontinuous process of rolling while all window glass is made by a wholly continuous drawing process.
3. Rough rolled plate glass in most cases is subjected to additional operations such as grinding and polishing giving it a plane, optically true surface.

Safety glass which is a fabricated product from either plate or window glass will also be discussed.

Courtesy of Pittsburgh Plate Glass Company

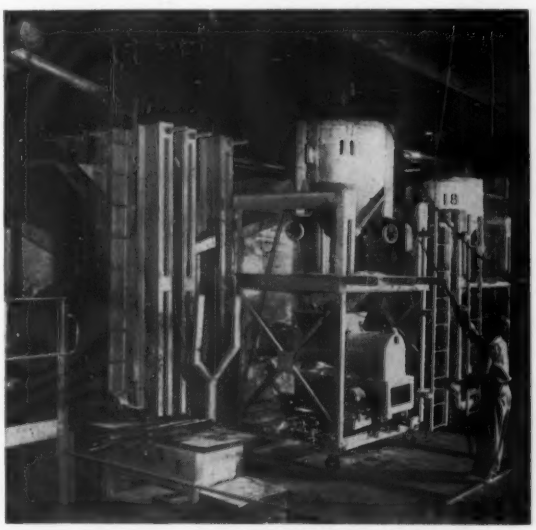
Figure 1 — Reproduction of first permanent English Colony glass works at Jamestown, Va.

PLATE GLASS MANUFACTURE

Manufacture of plate glass today is a highly automatic process involving specially developed and costly equipment. From the automatic weighing and mixing of raw materials to the intricate cutting and packing lines, this equipment is most important in maintaining highest quality production.

The principal raw materials used are soda ash, salt cake, sand, limestone, dolomite and cullet (broken glass recovered from previous glass making operations). These materials are stored in silos. Conveying equipment then automatically gathers the raw materials, weighs each to specific formula, mixes them into a batch and transfers this onto an endless moving belt. The belt dumps into one of a series of moving hoppers like those shown in Figure 2 which move the batch to the charging end of the melting furnace.

The timing and continuity of operations are very important, since plate glass production goes on for 24 hours a day, seven days a week. In modern plants, charging of the furnace, melting and withdrawal is continuous until the furnace needs relining. It is lined with refractory such as alumina which has a melting point higher than that of silica. However, constant subjection to high tem-



Courtesy of Henry F. Teichmann, Inc.

Figure 2 — Charging hoppers with raw materials.

Courtesy of Pittsburgh Plate Glass Company

Figure 3 — Plate glass forming rolls.

peratures in the range of 2800-3300°F causes deterioration and/or dissolution of the refractory.

Furnace melting temperatures, which are in the range of 2800°F, and charging cycles are maintained automatically from a central point to assure that the batch is "cooked" properly. This results in the finest quality plate glass production.

Rolling

One of the most spectacular of the plate glass operations is seen at the rolling end of the furnace as illustrated in Figure 3. At this point the plate glass begins to take shape. The molten glass flows from the furnace over a lip into the forming rolls. These rolls are large water-cooled electrically driven rolls and are faced with precision ground steel surfaces. The rolls rotate and roll the molten glass through, forming a semi-solid continuous ribbon of glass. Glass in widths up to 11 feet and of various thickness is produced by adjustment of the rolls. The glass as it enters the forming rolls is at a temperature of approximately 2100°F. From this point the semi-molten ribbon moves to a series of steel

Courtesy of Pittsburgh Plate Glass Company

Figure 4 — Annealing lehr and cooling system.

rolls where it cools slightly and solidifies into rough plate glass.

Annealing

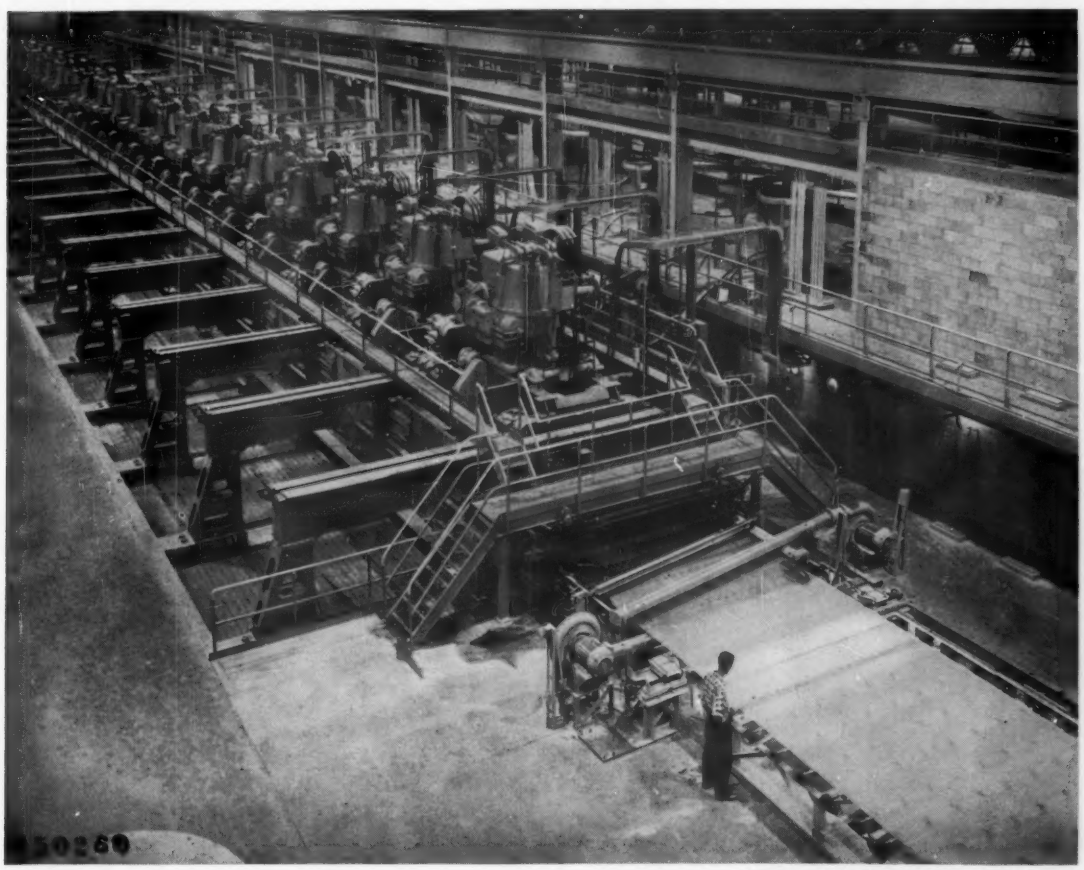
The glass ribbon then enters an *annealing lehr*. A lehr is a long heavily insulated oven-like tunnel which has a series of decreasing temperature zones. The purpose of this equipment is to control stresses and strains which could be set up in the glass if it were cooled too quickly. These temperature zones range from approximately 1200°F to 400°F. After leaving the annealing lehr, the glass ribbon enters a cooling area shown in Figure 4. It is gradually cooled to room temperature after travelling approximately 625 feet. Through the annealing process the glass acquires added strength and excellent working characteristics.

Grinding

After leaving the cooling area in a more modern plant the glass ribbon enters a battery of twin grinders shown in Figure 5. Here both of its surfaces are precision ground simultaneously to give the glass maximum optical-like quality. Grinding wheels are up to 11 feet in diameter as shown in Figure 5, and usually weigh about 8000 pounds. Material used for grinding is specially processed silica sand. Following the grinding, the glass is automatically cut into plates about 15 feet long and moved on a conveyor to the polishing lines.

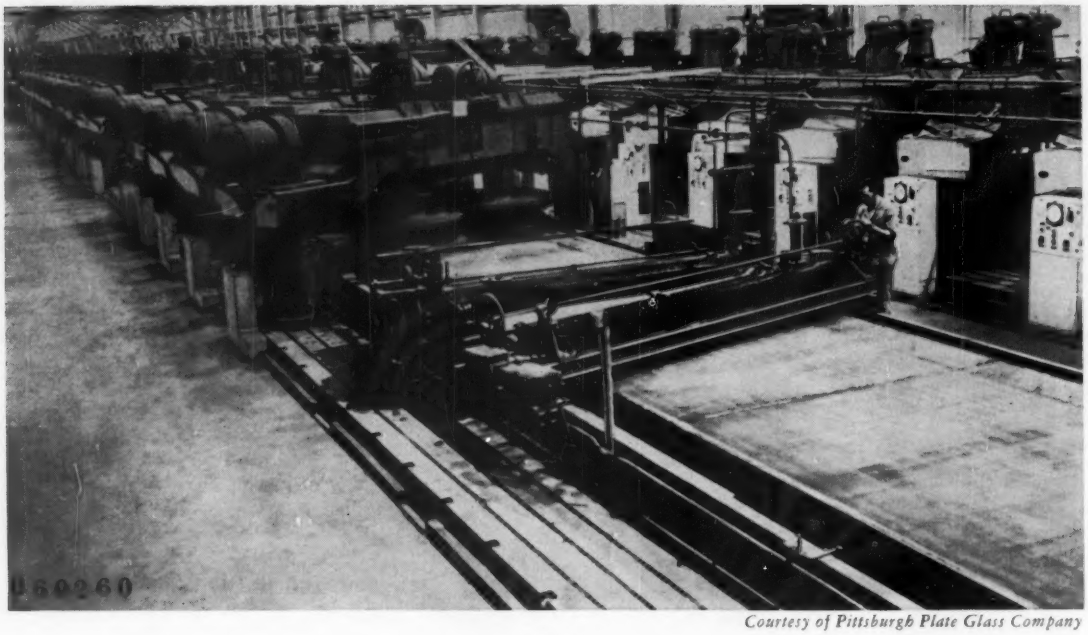
Polishing

The surfaces having been ground are ready for polishing. The polishing systems today are continuous and designed to increase polishing speeds appreciably. Ground plates are transferred from the conveyor to an endless moving line of cast iron "tables" which are covered with cloth to hold the plates firmly in place. The "tables" then move under a series of *polishing bridges* each with as many as nine rotating blocks as shown in Figure 6. A solution of copperas (iron sulfate) water and rouge is used to polish the ground glass to a beautiful transparent finish. *Vacuum cup cranes* are used to lift the plate to a conveyor after one side has been polished and washed. The conveyor moves it to a barrel



Courtesy of Pittsburgh Plate Glass Company

Figure 5 — A battery of twin grinders.



Courtesy of Pittsburgh Plate Glass Company

Figure 6 — Plate glass polishing lines.

"turnover" which automatically reverses the plate. This manipulation sends it to the second polishing line for the other side to be processed.

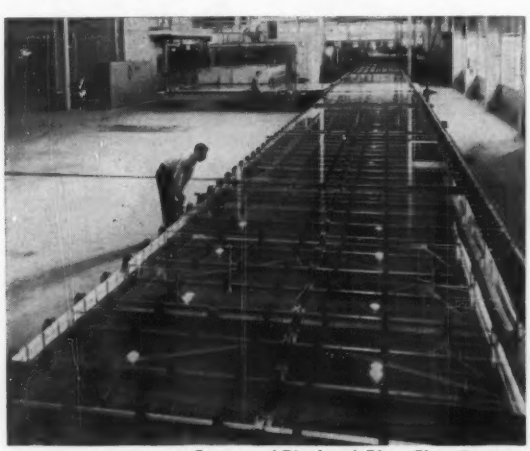
Cleaning and Cutting

Having been polished on both sides to a gleaming finish, conveyors like those in Figure 7 move the plates to the *wareroom*. Here with special cleaning equipment the plates are thoroughly cleaned with brushes and solutions and mechanically dried. The plates are then carefully inspected for imperfections. Perfect plates move on to an automatically controlled cutting mechanism for trimming or cutting into uniform blanks for later cutting to desired sizes.

In the final cutting operation the glass is conveyed to special cutting machines like that shown in Figure 8 where it is cut to predetermined size. Cutting operations are automatically controlled from a central master control panel which governs the size and quantity going through each machine. Following this operation the plate glass is again washed, dried, and inspected on machines like those illustrated in Figure 9. It is then moved on conveyor lines to the packing and shipping area.

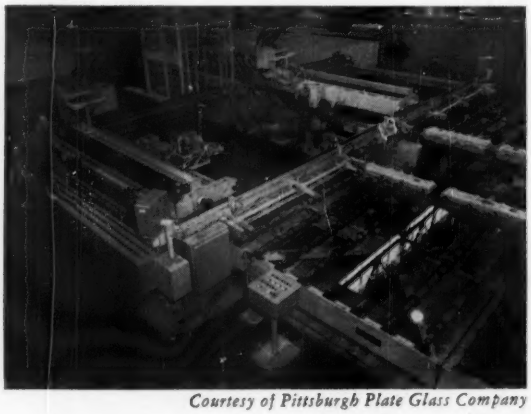
Packaging

The glass is raised above the conveyor belt and



Courtesy of Pittsburgh Plate Glass Company

Figure 7 — Polished plate glass entering the cleaning equipment.



Courtesy of Pittsburgh Plate Glass Company

Figure 8 — An automatic cutting line used for final cutting.

Courtesy of Libby-Owens-Ford Glass Company

Figure 9 — A plate glass cutting machine. The inspection section after cutting is shown in foreground with cullet box.

Courtesy of Pittsburgh Plate Glass Company

Figure 10 — Crating glass for shipment.

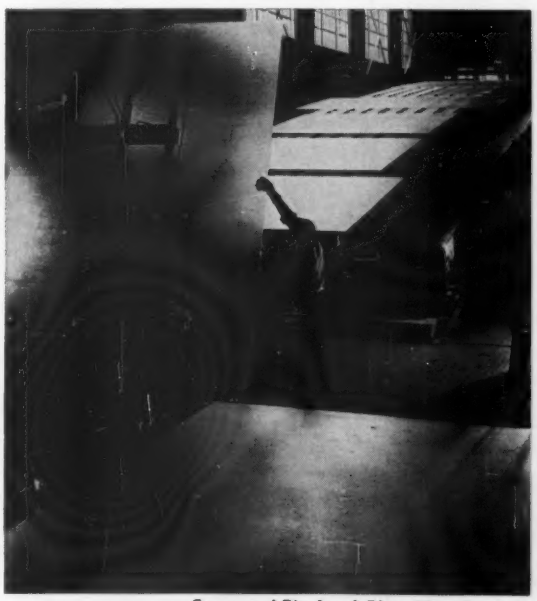
lifted by a *packer* shown in Figure 10 directly into boxes which are on special carts. A vacuum cup crane like that shown in Figure 11 is used to pack larger size plates of glass. The plates are picked up at the end of the cutting lines, moved forward and placed in crates on mobile platforms. After the lids have been put on, the crates are moved to the shipping docks.

Lubrication of Plate Glass Machinery

The chief lubrication problem in a plate glass plant is the selection of high temperature lubricants for machinery at the discharge end of the furnace and for bearings, chains and gears close to the hottest part of the furnace. Where oil is required for this machinery a carefully selected and refined mineral oil is recommended which has high flash and fire points, minimum tendency to vaporize, and low carbon residue. Unless a product of this nature is used, the heat might cause carbon accumulation which will interfere with oil circulation through bearing clearances. If the machinery is designed for grease lubrication a non soap thickened grease with a No. 2 NLGI consistency and a minimum dropping point of 500°F is recommended which will provide adequate protection for machinery exposed to radiant heat in the range of 1000 to 1500°F. Where temperatures higher than this are encountered, finely divided solids such as graphite, copper, brass, etc. are used in dispersion. The carrier oil for these latter materials can have a viscosity as high as 1800 seconds Saybolt Universal at 100°F. These are applied with squirt can or brush.

Lubrication in the rest of the plant is largely associated with lifting and conveying equipment which consists of gears, bearings, and wire rope. Enclosed spur or bevel gears can usually be lubricated with a lower viscosity product than where the installation is exposed. Normally a mineral or mild EP lubricant with a viscosity of 55 to 250 Seconds Saybolt Universal at 210°F can be used depending on service requirements. Where gears are exposed a lubricant with a viscosity of about 1000+ Seconds Saybolt at 210°F should be used. A lubricant with the latter viscosity should also be used for wire rope as governed by operating temperatures.

In order to obtain regular lubrication all equipment where possible is lubricated with a centralized pressure system for both oils and greases. The more effective lubrication which this system provides results in longer bearing life.



Courtesy of Pittsburgh Plate Glass Company

Figure 11—Vacuum cup crane for moving large plates of glass.

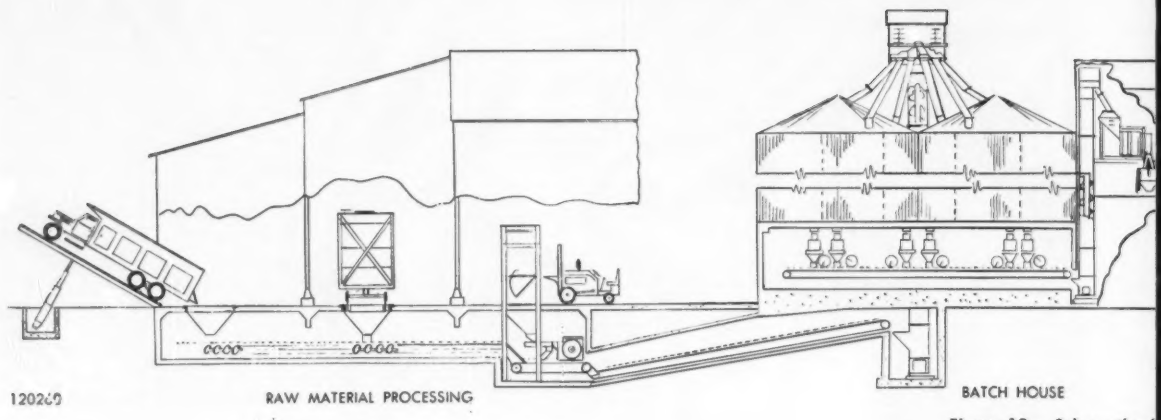


Figure 12 — Schematic sk

In grinding and polishing, lubrication is required for the motor bearings which drive the grinding and polishing parts, the reduction gears, and the guide bearings of the main shaft which extends down to the frame carrying the runners. After the glass has solidified and passed from the cool end of the lehr, discoloration or contamination of the product no longer has to be considered as much as when the glass was in the workable stages. However, expensive methods for preventing leakage of lubricant from bearings and gear housings are justified. Also, in the interest of economy, these housings are maintained as tight as possible through preventive maintenance.

Guide bearings of the grinding and polishing equipment are subjected to low loading and are usually lubricated with a well refined engine or machine oil with a viscosity of 300 to 500 Seconds Saybolt Universal at 100°F. The same oil can be used on the bearings of the driving gear shaft and also on the driving motors where the latter are designed for oil lubrication.

Attendant gearing for the operation of grinding and polishing equipment is best lubricated with a mild extreme pressure gear lubricant having a viscosity at 210°F of 950 Seconds Saybolt Universal. A more fluid product with a viscosity in the range of 150-200 Seconds Saybolt Universal at 210°F is used on lighter gears lubricated either by bath or automatic circulation of lubricant. However, when these gears are exposed they will function best if a heavier and more adhesive product is used.

Other plate glass handling equipment requiring lubrication includes the traveling mechanisms of the lehrs and overhead cranes used for handling the plates of glass. On this type machinery no difficulty is normally encountered with lubrication of the moving parts. A well refined machine oil with a viscosity of 200 to 300 Seconds Saybolt at 100°F is adequate for general bearing lubrication. Lubricants for gears are similar to those used for polishing and grinding machine drives. The correct viscosity of lubricant is chosen according to the type of housing, the load, and protection required. Gear oils with viscosities ranging from 150 to 2000 Seconds at 100°F are used. These include turbine type, polar compounded and mild EP oils.

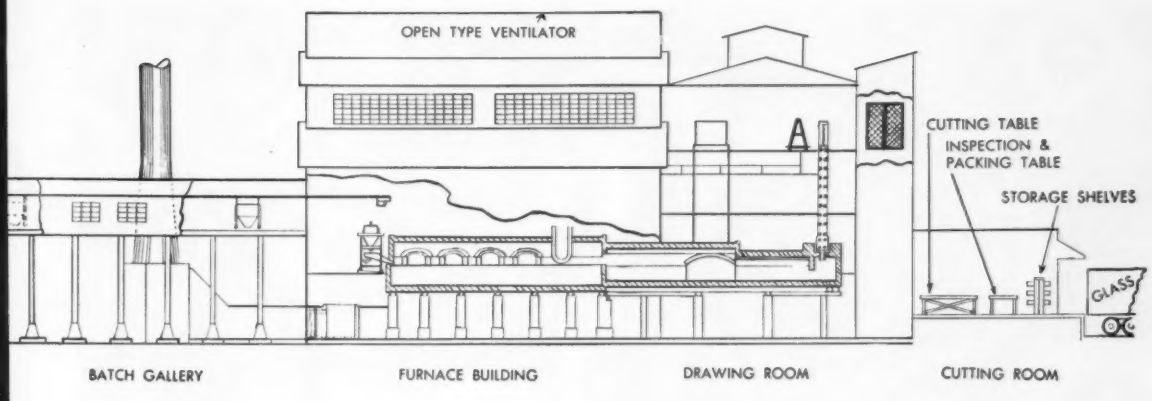
WINDOW GLASS MANUFACTURE

Many years ago window glass was made by spinning a blob of glass on the end of a rod into a flat disk, breaking off the rod (leaving the famous "bullseye" or "crown") and then cutting the flat disk into rectangular or diamond shapes. This resulted in small pieces more or less flat which would let light in, but were so full of distortions that one could not look through them. Today the manufacture of window glass is a highly automatic process which requires specially designed and costly equipment.

Window glass is made from the same principal raw materials used in the manufacture of plate glass. These materials are stored in extremely large concrete silos after they have been raised with specially designed equipment from rail cars.

As shown in Figure 12 which portrays a complete window glass plant, raw materials are moved by truck or automatically by continuous conveyor from the silos to the mixing area. These materials are mixed automatically in a dry batch to a specific formula and then moved to a large hopper at the melting tank. The tanks or furnaces are similar to those used for plate glass manufacture but are usually smaller.

The raw materials are fed continuously into the melting furnace and reduced to molten glass. The end into which the materials are fed is the charging end while the other end of the rectangular furnace is known as the drawing end. Melting of glass



Courtesy of Henry F. Teichmann, Inc.

of window glass plant.

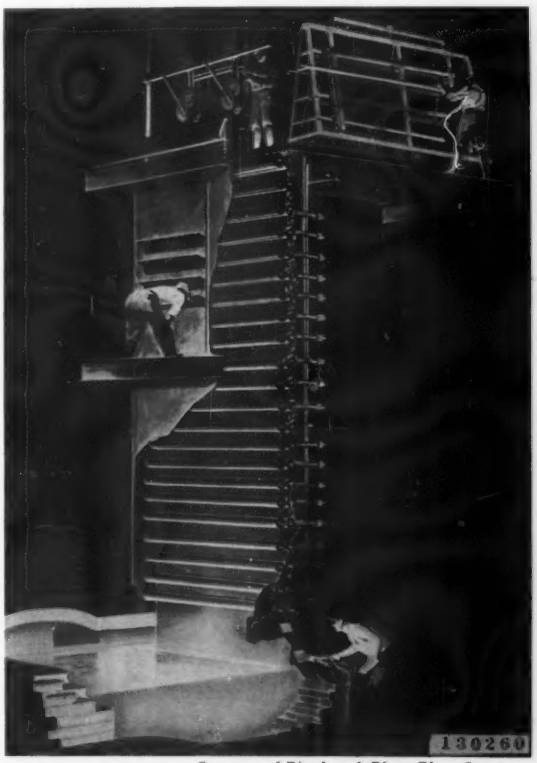
for window glass is a continuous operation extending up to 40 months. While the batch is melting, proper temperatures are maintained with an intricate pyrometer system.

Vertical Drawing

The "heart" of the window glass process is the continuous vertical drawing machine shown in Figures 12 and 13 which is located over the drawing end of the furnace. To initiate drawing, a metallic hook called the "bait" is lowered into the molten glass and then drawn slowly upward. The adhering charge is gathered in a few seconds. As the hook moves, the molten glass adheres first in thin strands because of its surface tension and viscosity and then in a full sheet 90 inches wide. Before it reaches the first roll, the viscous glass is hardening and has a brilliant, fire-polished finish. Unlike most other materials, glass does not have a definite melting point where it is solid at one temperature and liquid at a slightly higher one. On the contrary it behaves like a fluid since, as temperature decreases, it merely becomes more viscous and less plastic. This characteristic permits working it almost like a high temperature thermo-plastic. Thickness of the glass is controlled by the speed of drawing and by spacing of the first rolls it comes in contact with after leaving the furnace. The sheet as it is drawn upward from the furnace, passes between successive sets of gear-driven rolls which carry the continuous sheet of glass about 40 feet above the melting furnace to the process floor where the cutting operations take place.

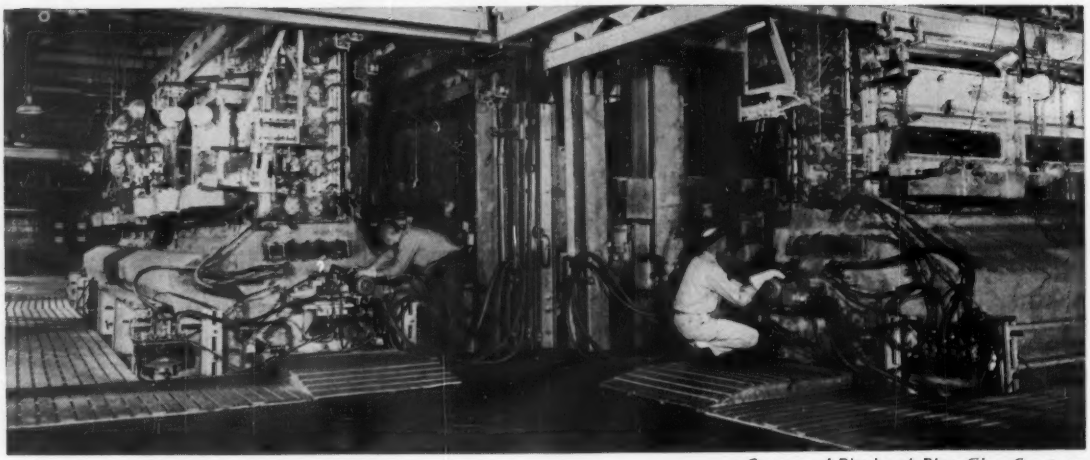
Cutting

Figure 14 shows three drawing machines being fed from one furnace. As shown in Figure 15, the sheet rises until it is automatically cut as it comes through the opening in the floor, into predetermined sizes up to a maximum of 120 inches square. An automatically controlled "laydown" arm places the cut sheets on a conveyor leading to automatic cutting and inspection equipment. The large sheet of glass on the rubber-wheeled conveyor shown in Figure 16 is of ⅛ inch thickness. Since the knurled edges (which occur during the drawing operation) have already been trimmed, it will move on to auto-



Courtesy of Pittsburgh Plate Glass Company

Figure 13 — A vertical drawing machine for making window glass.



Courtesy of Pittsburgh Plate Glass Company

Figure 14 — A furnace may have one to four drawing machines. Three machines are shown here.

matic cutting into smaller sizes and then by automatic conveyor to packing.

Horizontal Drawing

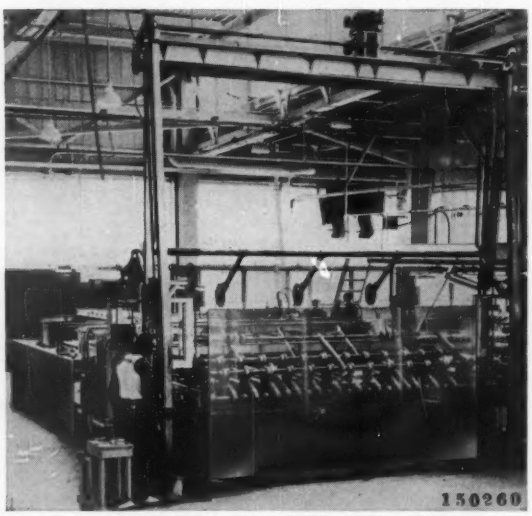
This drawing operation is also continuous. A continuous sheet of glass is drawn from the melting furnace over horizontal rolls and through a long lehr in the same plane. In this process the starting "bait" is an iron bar several feet long. This bar is lowered into the molten glass each time a charge is to be gathered. It is then raised a few feet to permit drawing of the charge over a roller. The charge is then pulled horizontally by the "bait" into the lehr which may be more than 200 feet long. Thickness of the glass in this type drawing is also controlled by the speed at which the glass is drawn and spacing between the first rolls. The "bait" of course is cut away as soon as the sheet has been drawn to the desired length. This sequence is repeated for obtaining additional sheets of glass. From the lehr the sheet is conveyed to the cleaning and cutting areas and then is ready for packaging.

Packaging

Packaging positions are located at the end of the automatic cutting and inspection lines. Figure 17 shows high quality window glass being conveyed to the packing area where it is boxed or crated. To protect the surface of the glass in shipment each piece is separated by newsprint paper. Figure 18 gives a view of machinery for cutting the paper.

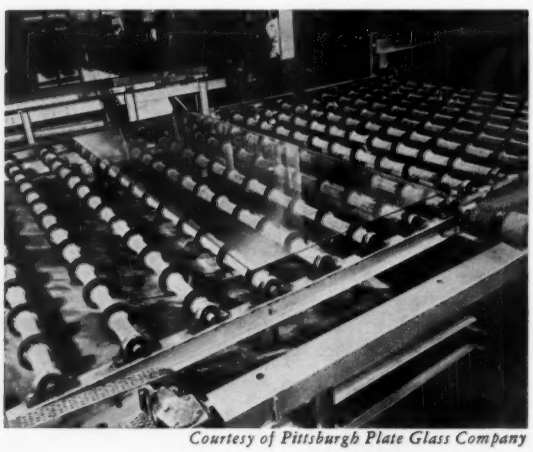
Lubrication of Window Glass Machinery

In the manufacture of window glass, the mixing



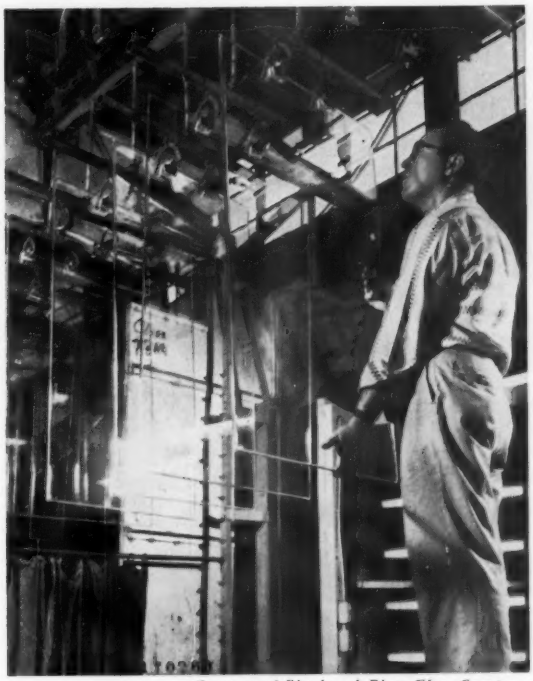
Courtesy of Pittsburgh Plate Glass Company

Figure 15 — A sheet of glass being automatically cut as it comes through opening in floor.



Courtesy of Pittsburgh Plate Glass Company

Figure 16 — A rubber wheeled conveyor which moves the glass to another automatic cutting operation to smaller sizes.



Courtesy of Pittsburgh Plate Glass Company

Figure 17 — A conveyor moving double-glazed insulating windows from end of production line.

equipment, forming rolls, cutting machines, handling machinery, motors and auxiliaries, such as blowers, compressors and gas producers require lubrication. The normal lubricants used in a power plant for the latter equipment are used in the glass plant also.

For the motor bearings of electric motors driving blowers, compressors, gas producers and for the bearings of these latter pieces of equipment, the following lubricants are used:

Plain bearings

Oil lubricated	Mineral oil having a viscosity of 150-350 seconds Saybolt Universal at 100°F.
Grease lubricated	An NLGI No. 2 premium grade multipurpose grease
Ball or roller bearings	An NLGI No. 2 premium ball and roller bearing grease

Glass making machinery in the furnace area is subjected to heat conditions which must be considered when selecting the lubricants. The lubricants which should be used are the same for this equipment as those previously described in greater detail for plate glass machinery subjected to heat conditions.

Lifting and conveying equipment is made up of an assembly of gears, bearings, chains and wire rope. Lubricating requirements for gearing are dependent on the type of housing. Enclosed spur or bevel gears can usually be lubricated with a lower viscosity product than where the installation is exposed. Normally a straight mineral or EP lubricant with a viscosity between 55 and 250 Seconds Saybolt Universal at 210°F is used satisfactorily in a bath-lubricated housing. However, for exposed gears a lubricant with a viscosity of about 1000+ Seconds Saybolt Universal at 210°F should be used. The heavier lubricant adheres more readily to the gear teeth which results in more economical lubrication. Depending on operating temperatures lubricants like those described above can also be used for wire rope.

To adequately lubricate the worm and wheel of worm gears, a lubricant having the mild E.P. properties commonly obtained from lead soaps and/or polar materials is used. The lubricant should have a viscosity of 150 to 200 Seconds Saybolt Universal at 210°F. A lubricant with a viscosity of about 100 Seconds Saybolt Universal at 210°F is used for worm gear reducers operating at lighter loads or where design of the unit permits.

The anti-friction bearings of the lifting and conveying equipment require a well refined mineral oil having a viscosity of 200 to 300 Seconds Saybolt at 100°F. Ring-oiled electric motor bearings can be satisfactorily lubricated with the same oil. Where grease is required an NLGI No. 2 consistency is generally used in a pressure gun or a centralized lubrication system.

The forming rolls used in rolling operations consist of two rolls with bearings on each end. These rolls have special watercooled anti-friction bearings which are lubricated with a well refined mineral oil. An oil having a viscosity of 55 to 100 seconds Saybolt Universal at 210°F and good oxidation stability is used. Where these bearings are designed for grease lubrication the more thermally stable greases are used.

Courtesy of Pittsburgh Plate Glass Company

Figure 18 — Machinery for cutting newsprint paper used to pack window glass.

Courtesy of Pittsburgh Plate Glass Company

Figure 19 — Plate glass being cut into the desired shapes for making safety windshields.

Where elevated temperatures of 1500°F and upwards are experienced in operation, solid lubricants are used in dispersion. These solid lubricants include small particles of graphite, copper, brass, etc. in a carrier oil which can have a viscosity as high as 1800 seconds Saybolt Universal at 100°F.

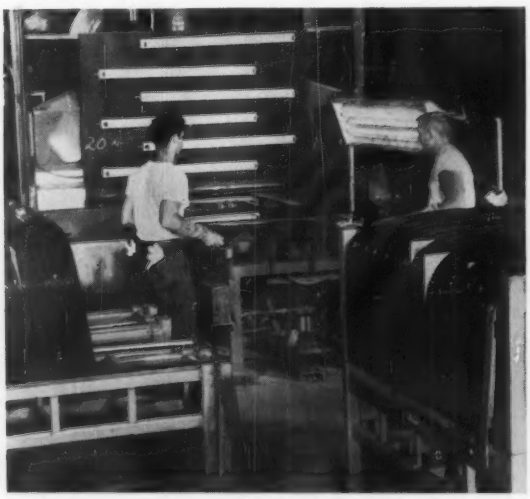
SAFETY GLASS MANUFACTURE

This type glass is made from either plate or window glass and can be either laminated or tempered. Laminated plate glass is composed of two or more pieces of plate or window glass with inner layers of tough transparent plastic which have been bonded together by heat and pressure. If broken, the glass will not fly off nor will there be any sharp splinters or cutting edges exposed. Tempered safety glass is either plate or window glass having high compression of its surfaces resulting from rapid heating followed by instant cooling. When the limit of its high mechanical strength is reached, tempered glass crumbles into small granular fragments with somewhat smooth edges which do not cut. Glass of the foregoing types is used in a number of applications ranging from automobile windshields and windows to multiple layer aircraft glass.

Courtesy of Pittsburgh Plate Glass Company

Figure 20 — Two pieces of glass being matched for pressing on bending irons.

In making safety windshields for automobiles, the plate glass is first cut into the desired shape and accurate size with a cutting machine like that shown in Figure 19. The glass is next thoroughly cleansed and dried to prepare it for "bending". Two pieces of glass are matched, as shown in Figure 20,



Courtesy of Libby-Owens-Ford Glass Company

Figure 21 — Starting cut pieces of plate glass through the bending lehr.

Courtesy of Pittsburgh Plate Glass Company

Figure 22 — Windshields from the lehr being moved by conveyor to the laminating area.

Courtesy of Pittsburgh Plate Glass Company

Figure 23 — Removing excess moisture from the plastic to be used as the inner layer for laminated glass.

then placed on "bending irons" and conveyed through a lehr or oven where heat softens the glass and allows it to "bend" to the proper shape. After passing through the lehr, shown in Figure 21, the pieces are transported by conveyors like those in Figure 22 to the laminating area. Speed of the conveyor is regulated for cooling the glass sufficiently to permit handling in the last operation. During the time the glass is being prepared, the plastic inner layer is made ready by running it through equipment like that shown in Figure 23 which removes excess moisture from the plastic. Figure 24 shows the inspection of color-shaded plastic interlayers.

Courtesy of Libby-Owens-Ford Glass Company

Figure 24 — Plastic inner layer being examined and stacked in preparation for assembly and lamination.

Courtesy of Pittsburgh Plate Glass Company

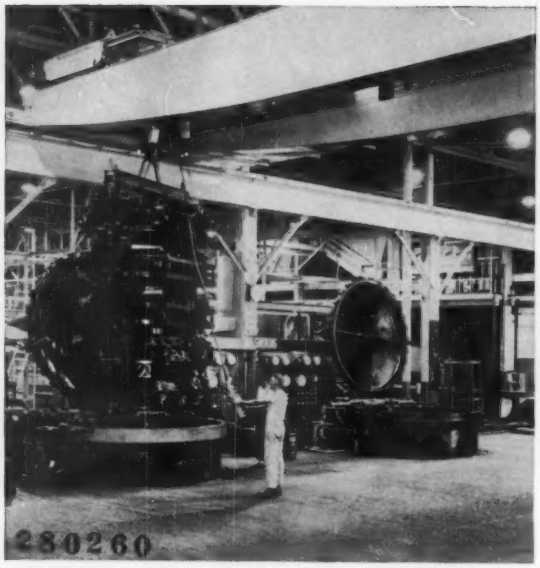
Figure 25 — Matched pieces of glass and plastic being assembled into one unit.

Courtesy of Libby-Owens-Ford Glass Company

Figure 26 — Assembly of glass and plastic sandwiches for smaller units of laminated auto glass.

Courtesy of Pittsburgh Plate Glass Company

Figure 27 — The translucent windshield after preliminary pressing.



Courtesy of Libby-Owens-Ford Glass Company

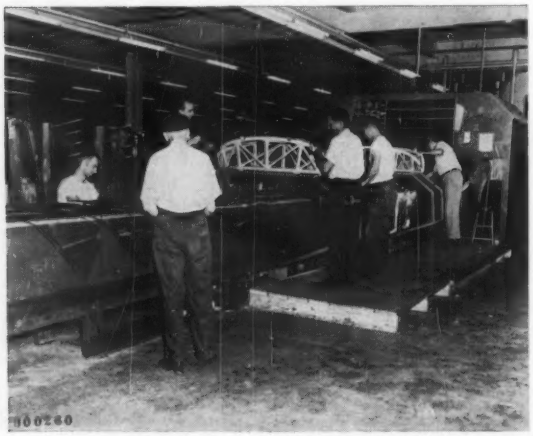
Figure 28 — Huge autoclaves for laminating windshields.

Figure 25 illustrates the assembly of the plastic between the two matching curved glass sheets. Figure 26 shows the similar assembly of smaller glass-plastic "sandwiches" like those used in wind deflectors and side windows.

After clamping, a glass-plastic windshield assembly passes through several other operations, one of the most important being the preliminary pressing in which the assembly is passed through a lehr held at about 100°F and rolled with hard rubber rollers as it passes through. This rolling eliminates the air space between the glass and plastic which prevents oil from getting in between the two materials during subsequent treatment in the autoclave. As Figure 27 illustrates, the windshield-to-be is only translucent at this stage. The preliminary pressed windshield is then put into an autoclave like one of the two shown in Figure 28 which are like huge pressure cookers. A paraffinic oil having a flash point of about 370°F, a viscosity of 100 Seconds Saybolt Universal at 100°F, and low carbon residue is used in the autoclave. The "boiling" oil at 250°F and pressure in the range of 60-70 psig force the glass and plastic into permanently sealed safety glass and make it perfectly transparent. Figure 29 shows a conveyor transporting flat laminates to the next process. After special washing to remove the oil on the outside of the sealed safety glass, the windshields are inspected as shown in Figure 30, packed or crated, and shipped throughout the world.

Courtesy of Libby-Owens-Ford Glass Company

Figure 29 — Intricate conveyors moving small laminated auto glass parts between operations.

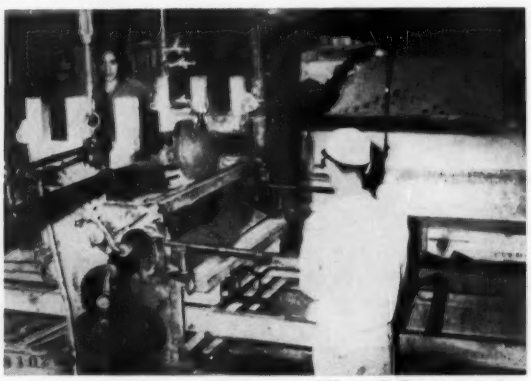


Courtesy of Libby-Owens-Ford Glass Company

Figure 30 — Final inspection of windshields prior to packing or crating.

Wire Glass

Another type of safety glass is the familiar "wire" glass which contains a wire netting within the glass itself. This glass is made in smaller quantities than



Courtesy of Henry F. Teichmann, Inc.

Figure 31 — A "wire" glass machine

TABLE I

Types of Additives in Glass Mill Lubricants

Glass Mill Lubricants	Types of Additives Used	Purpose of Additives
EP Greases	Calcium, lithium and sodium soaps	Thickening agents
	Chlorine, lead phosphorus or sulfur compounds	Provide for extreme pressure
	Polar compounds	Used in presence of water to improve lubrication
	Oxidation inhibitor	Oxidation resistance
High temperature greases (with and without conventional fillers)	Clay, bentonite, silica, and other gelling agents.	Provide high dropping point and as thickening agent
	Oxidation inhibitor	Oxidation resistance
Medium temperature greases	Calcium complex, soap and synthetic thickeners	Thickening agents
	Graphite	Assist in rough lubrication
Cup Greases	Calcium soap	Thickening agent
Ball and Roller Bearing Greases	Rust inhibitor	Eliminate rusting in presence of water
	Mixed calcium and sodium, lithium and sodium soaps	Thickening agents
	Oxidation inhibitor	Oxidation resistance
Gear Oils — EP	Chlorine, lead, phosphorus and sulfur compounds	Provide for extreme pressure
Heavy Duty	Polar compound	Used in presence of water to improve lubrication
	Rust inhibitor	Eliminate rusting in presence of water
	Anti-foam compound	Minimize foaming
Gear Oils (Cut back)	Petroleum thinner, chlorinated solvent or coal tar solvent	Provide for ease of application
Heavy Duty Motor Oils and Diesel Lubricating Oils	Pour Depressant	For easy cold weather starting
	Viscosity Index Improver	Increase viscosity index
	Anti-foam compound	Minimizing foaming
	Detergent	Maintain engine cleanliness
	Oxidation inhibitor	Oxidation resistance
	Corrosion inhibitor	Prevent bearing corrosion
Turbine Oils, Hydraulic Oils	Oxidation inhibitor	For long oil life
	Extreme Pressure Agents	Provide for extreme pressure, especially in reduction gears
	Rust inhibitor	Rust resistance
	Anti-foam compound	Minimize foaming
Compressor Oils	Oxidation inhibitor	Oxidation resistance
	Polar Compound	Improve lubrication — presence of water
	Rust inhibitor	Rust resistance
Steam Cylinder Oils (compounded)	Fatty materials such as tallow or lard	Effect better lubrication of cylinders exposed to wet steam conditions
	Pour depressant	For easier handling at low temperatures
Thread Compounds	Powdered lead, copper, zinc, graphite	Prevent thread galling. Provide good seal under pressure
Fire resistant hydraulic fluids	Rust inhibitor	Rust resistance
	Anti-foam compound	Minimize foaming
	Oxidation inhibitor	Oxidation resistance

polished plate glass but is being used more extensively each year for construction work. It is reported that as a fire retardant, wire glass has probably saved more lives and property since its use was begun than any material known. It can be made by either the "sandwich" or by the "solid" processes. The "sandwich" process consists of rolling a thin sheet from molten glass, laying the wire net over its surface, then rolling a second thin sheet of molten glass over the wire. In the "solid" process glass is poured onto the wire and the whole rolled to the desired thickness. The roller forces the fluid glass through the wire meshes to join it again beneath it. A more satisfactory adaptation of the "solid" process is to pour the molten glass into a cast iron trough and allow it to flow downward through rolls onto a table. The wire is fed simultaneously with the glass as they pass through the rolls. Figure 31 shows a "wire" glass machine.

Lubrication of Safety Glass Machinery

In the making of safety glass the cutting machines, conveyors, lehr traveling mechanisms and overhead cranes each have bearings and gears which must be lubricated; however no particular problems are encountered with lubrication of these bearings and gears. A well refined machine oil with a viscosity of 200 to 300 Seconds Saybolt Universal at 100°F is used for the bearings. Lubricants for gears are similar to those used for polishing and grinding machinery described previously. Gear oils which will give the protection required are in a viscosity range of 55 to 250 Seconds Saybolt Universal at 210°F. The correct viscosity is chosen according to the type of housing and load to which the gears will be subjected. Some bearing and chain units are also lubricated using oil-mist lubrication.

In addition, the bearings of the motor drives and reduction gearing of safety glass machinery are also involved. Where the bearings are designed for oil lubrication, a well refined engine or machine oil with a viscosity of 200 to 300 Seconds Saybolt Universal at 100°F is used. In bearings designed for grease, a medium consistency product which can be used in a pressure gun or centralized lubricating system and withstand fairly high temperatures is preferred. Based on experience a well refined mild EP oil will give best protection for large spur or herring-bone type enclosed or semi-enclosed reduction gears. The viscosity of the lubricant is in the same range of an extra heavy motor oil to a steam cylinder oil depending on the load and speed to which the gear is subjected. Worm reduction gear manufacturers, however, recommend compounded lubricants like a steam cylinder oil containing a small per cent of animal fat or a non-corrosive lead soap type lubricant.

ADDITIVES IN GLASS MILL LUBRICANTS

Additives are chemical compounds added to lubricants to give new properties or improve properties already present. In addition to giving more concern to providing the most efficient lubrication for machinery operating in the presence of water or extreme heat conditions, the modern tendency to speed up machines has also required that additives be included to provide proper lubrication. Table I shows the types and functions of a number of types of additives which might be used in glass mill lubricants.

The use of additives in lubricants should be left to the lubricant manufacturer since he is best equipped for determining the type and amount needed to give optimum results.

SUMMARY

In the glass industry, due to the nature of the work involved, most of the machinery is of very heavy duty and of rugged construction. While glass manufacture is a precision operation, the equipment must also be designed to operate under severe temperature and pressure conditions. No matter what type or shape is required, the final glass product must be made to precise dimensions. Machinery for this purpose must function in a synchronized procedure through perfect coordination of the working parts. Without effective lubrication perfect coordination is practically impossible.

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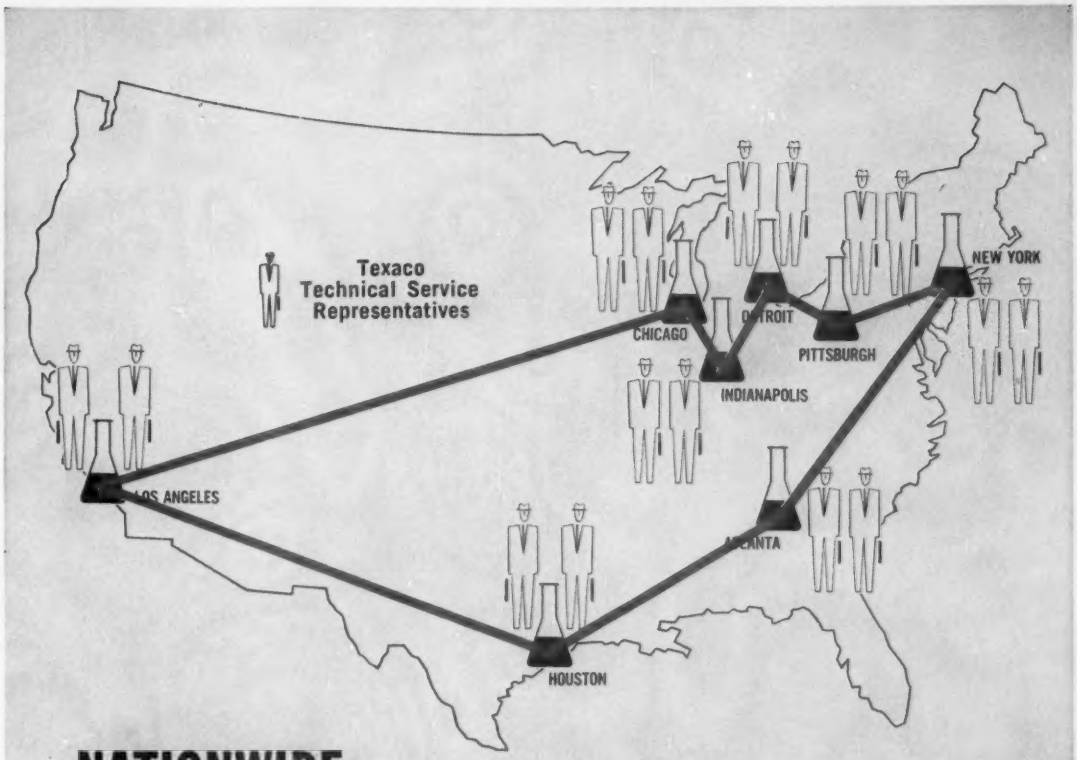

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